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CRITERION DEVELOPMENT AND APPLICATION

A Comparative Multidimensional Scaling Analysis of the Tasks Performed
by Naval Aviation Electronics Technicians at Two Job Levels

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ABSTRACT

This study investigated the application of multidimensional scaling methods in the area of job performance. Supervisory personnel judged the similarity among all pairs of 29 tasks which had been designated as constituting the job of the Naval aviation electronics technician supervisor. The resulting scaled similarity estimates were analyzed by multidimensional scaling techniques.

This research supplemented an earlier study by providing further evidence that it is feasible and fruitful to apply multidimensional scaling methods to Naval job performance. Chief petty officers and petty officers, first class, in the aviation electronics technician rating perceived their work as involving nine basic dimensions, including all the dimensions underlying the job of strikers and petty officers, third class, in the rating.

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As in the previous study, Dr. David R. Saunders performed the factor analytic calculations on a high-speed computer. At Applied Psychological Service Miss Marita Viglione carried out the initial tabulations and scaling computations and Miss Gail Gensemer and Mrs. Estelle Siegel provided secretarial and administrative support.

We wish to express our gratitude to all these people for their important contributions to this project.

Arthur I. Siegel
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CHAPTER I

INTRODUCTION

Recent research carried out by Applied Psychological Services in the area of criterion development has emphasized the application of psychological scaling methodology to job performance measurement. Earlier studies had produced comprehensive, detailed check lists for evaluating the post-training job performance of Naval enlisted personnel in several technical specialties. Psychological scaling techniques appeared to offer promise as a means for constructing short, convenient-to-use instruments and for obtaining further insight into the basic structure of the job. The first efforts along these lines (Schultz and Siegel, 1961; Siegel and Schultz, 1962) examined the applicability of the Thurstone and Guttman scaling methods in performance criterion development.

The most recent report (Schultz and Siegel, 1962) described a multidimensional scaling analysis of the job performance of Naval aviation electronics technicians. In that report it was pointed out that job criteria have generally been found to be complex and multidimensional but that this problem area required further quantitative consideration and methodological exploration. In these respects multidimensional scaling analysis seemed particularly appropriate, since its primary purpose is to determine the number and characteristics of the dimensions underlying the phenomenon which is being analyzed.

Torgerson (1952, 1958), Messick (1956a, 1956b), and others have given the details of the derivative and computational procedures used in multidimensional scaling analysis. Its essential rationale and some of the technical issues involved were discussed in the previous Schultz and Siegel report (1962). In brief, the structure of multidimensional scaling rests upon estimates of the psychological distances among the stimuli being studied. These have usually been obtained on the basis of judgments, by appropriate subjects, of the over-all similarity between each stimulus pair included in the phenomenal descriptive constellation. The scale values resulting from these judgments are then taken as measures of the inter-stimulus distances in a Euclidean space and the central analytical problem becomes first, the determination of the number of axes, or dimensions, in the space and, second, the projections of the stimuli on the axes.

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personnel in that rating formed the data substrate. Four basic job dimensions emerged from the analysis. The matrix of task loadings on the various dimensions suggested the names "electro-comprehension," "equipment operation and inspection (routine)," "electro-repair (simple)," and "electro-safety" for the four dimensions. It was felt that these dimensions described the technical job activities of the aviation electronics technician striker and petty officer, third class, adequately and meaningfully. Furthermore, it was concluded that the four dimensions possess characteristics such that it should be possible to develop unidimensional scales for the evaluation of individuals on each isolated and identified dimension.

The first study further indicated that it is feasible and fruitful to apply multidimensional scaling techniques to a job task constellation. In order to provide a firmer empirical base for the acceptance or rejection of this conclusion, application of the procedures to another set of job-task stimuli seemed desirable. For this purpose, attention was directed to the manner in which chief petty officers and petty officers, first class, in the Naval aviation electronics technician rating view their own job. The results of such a study would also permit a comparison, from the point of view of supervisory personnel, of the job dimensional characteristics at the supervisory and the journeyman* levels of aviation

* Throughout this report the term "journeyman" is used to refer to a striker or a petty officer, third class, in the rating. The term "supervisor" refers to a chief petty officer or a petty officer, first class.

electronics technicians and thus throw light on the basic structure of the rating as a whole.

Purposes of the Present Study

The specific purposes of the present study paralleled those of the first application of multidimensional scaling techniques in the job performance area (Schultz and Siegel, 1962). They were to: (1) explore further the feasibility of applying standard multidimensional scaling procedures to a job task constellation, (2) investigate more fully specific methods for applying these techniques in the work oriented situation, and (3) determine the number and the nature of the dimensions of the job of the Naval aviation electronics technician supervisor. A fourth purpose was to compare the dimensional structure of the aviation electronics technician job at the supervisory and the journeyman levels.

CHAPTER II

DEVELOPMENT AND ADMINISTRATION OF TASK LIST

Since the study presented here was very similar in purpose to the previous Applied Psychological Services' investigation into the aviation electronics technician's job (Schultz and Siegel, 1962), some of the preliminary work for both programs was carried out in parallel and there was overlap in content and style between the data collection forms used. Therefore, to make this description complete some material from the previous report is reviewed in this chapter.

Preliminary List of Tasks

In order to provide the "raw material" for the multidimensional analysis, it was necessary to derive a list of tasks which could be said to constitute the job of chief petty officer and petty officer, first class, in the Naval aviation electronics technician (AT) rating. The tasks were to be stated in behaviorally oriented terms with sufficient detail to reflect adequately the work performed, yet with sufficient generality to make feasible the required similarity judgments. In addition, reference to specific equipment was to be avoided so that neither general nor specific "equipment" factors would be generated.

A preliminary list was developed, based largely on three previous Applied Psychological Services' studies of aviation electronics technicians (Richlin, Siegel and Schultz, 1960; Schultz and Siegel, 1961; Siegel and Schultz, 1962). Since those studies had concentrated on journeyman level personnel it was necessary to

supplement the list with tasks that were thought, from Applied Psychological Services' background in the field, to be performed by AT supervisors but not by the lower level personnel. The complete preliminary list of 40 tasks has been presented in the previous report by Schultz and Siegel (1962).

Final Selection of Job Tasks

The 40 tasks were assembled in booklet form. The booklet was administered, in two groups, to 23 instructors in the AT school at the Naval Air Technical Training Command in Memphis, Tennessee. It could be assumed that these men knew the job under consideration since they were chief petty officers or petty officers, first or second class, in the AT rating and all had recently arrived at the school from Fleet duty. On the average, the instructors had about 7-1/2 years of military experience in electronics or electrical work, had about 5-1/2 years experience as an AT and had been assigned as an AT to about 2-1/4 different squadrons during their careers.

On the cover page, the booklet gave the following explanation of purpose and directions:

The purpose of this questionnaire is to determine the specific tasks AT's perform in the Fleet. We want to obtain a list of the jobs done by a representative sailor in this rating.

First, look over the list to get an idea of what tasks are included. Then:

1. Go through the list and check in the column labeled "AT Striker/3rd Cl. " all the tasks which are normally and customarily performed by Striker and Third Class AT's in the Fleet.
2. Go back and place a check in the second column next to all the tasks which are normally and customarily performed by First Class and Chief AT's in the Fleet.

You may know of a particular sailor who has done some of the listed tasks, even though most AT's do not do them. Or, in a particular squadron with which you are familiar, the AT's may perform certain duties not normally performed by most of the men in the rating.

The administrator emphasized that such tasks were not to be checked.

The directions concluded,

If there are any tasks normally performed by AT's in the Fleet which are not included in the questionnaire, please write them in under "Other" on the last page. Be sure to check whether these tasks are done by Strikers and Third Class men or by First Class men and Chiefs or by both.

This final instruction permitted the addition of any important AT activities which had been omitted inadvertently from the initial group of 40 tasks.

Before the men began working on the booklets, the administrator again stressed the point that a complete picture of the job as it is actually performed was wanted, rather than as it is supposed to be performed according to any criterion whatsoever. After the men had finished the form, an informal discussion was held to determine their estimate of the over-all completeness of the list and to obtain suggestions about such matters as the wording of the tasks. From the comments made during these sessions, it appeared that there was

general agreement among these "experts" that their responses reflected the work done by AT's in the Fleet accurately and adequately.

The instructors added no significantly new tasks in the spaces provided for "other" tasks. The consensus clearly indicated 29 of the 40 tasks as constituting the AT job at the chief petty officer and petty officer, first class, level. The other items were checked with varying frequencies but 19 or more of the judges agreed that the 29 tasks were performed by AT supervisors. These data, therefore, strongly supported the conclusion that the AT supervisory job was perceived by these widely experienced men as comprising the 29 tasks they had checked. The following 29 tasks, therefore, formed the basis for the multidimensional scaling analysis of the job performance of Naval aviation electronics technician supervisor

1. Standing watch
2. Performing major inspections of avionic equipments
3. Operating avionic equipments
4. Using safety precautions on equipment
5. Using proper safety precautions for self
6. Performing inflight maintenance on avionic equipments
7. Repairing malfunctioning parts/equipment in shop
8. Following block diagrams for avionic equipments
9. Using schematics for standard circuits in avionic equipments
10. Using schematics for complex circuits in avionic equipments

11. Analyzing standard circuitry in avionic equipments
12. Analyzing complex circuitry in avionic equipments
13. Troubleshooting/isolating malfunctions in avionic equipments
14. Making out reports (failure, etc.)
15. Using maintenance manuals
16. Using inspection and operation manuals
17. Operating standard test equipment for determining malfunctions in avionic equipments
18. Operating specialized test equipment for determining malfunctions in avionic equipments
19. Using ASO catalog and Section R allowance list for replacement parts
20. Employing electronic principles involved in the maintenance of avionic equipments
21. Knowing relationship to other related equipment of avionic equipments
22. Instructing others in the operation of avionic equipments
23. Instructing others in the inspection of avionic equipments
24. Instructing others in the maintenance of avionic equipments
25. Supervising operation of avionic equipments
26. Supervising inspection of avionic equipments
27. Supervising maintenance of avionic equipments
28. Keeping record of maintenance usage data
29. Assigning duties to personnel

A comparison of the above list with the analogous list from the journeyman level analysis reveals that nine tasks were included in both lists. These tasks, which are performed by both supervisors and journeymen in the AT rating, according to the judges, are: standing watch, operating avionic equipments, using safety precautions on equipment, using proper safety precautions for self, following block diagrams for avionic equipments, using schematics for standard circuits in avionic equipments, making out reports (failure, etc.) using inspection and operation manuals, and operating standard test equipment for determining malfunctions in avionic equipments. The tasks done only by the strikers and petty officers, third class, involve the simpler duties such as "housekeeping" chores, routine line operations, routine inspections, removal and replacement, and preventative maintenance. On the other hand, the chief petty officers and petty officers, first class, carry out a variety of more complex activities such as major inspections, troubleshooting and repair, operating test equipment, using schematics and analyzing circuitry, as well as administrative duties such as supervising, instructing, keeping records and assigning duties.

The Multidimensional Scaling Form

The 29 tasks designated as comprising the AT supervisory job were arranged in a booklet, called Form C of the Technical Task Inventory, so that estimates of the similarity between each pair of tasks could be obtained, in group administrations, from judges. At the top of each page, 1 of the 29 tasks was shown. Below it at the left side of the page, from 1 to all (28) of the remaining

tasks were listed. Since the psychological distance between each pair of tasks was judged in only one direction, i. e., from task A to task B and not from task B to task A, it was not necessary to show a task on later pages after it had been used at the top of a page. The tasks on any page were listed in a random order which was varied from one page to another.

To the right of each item there appeared a scale running from 1 to 11. The scale points 1 and 2 were described as representing a judgment of "very similar"; points 3, 4, and 5, as representing "moderately similar"; points 7, 8, and 9, as representing "moderately different"; and points 10 and 11, as representing "very different." Scale point 6, in the middle of the range, was unlabeled. The booklet page which contained all the tasks is shown as Table 1; a sample of the other pages is shown in Table 2.

The directions asked the subject to compare each task listed with the one shown at the top of the page and then to "indicate by a check in the appropriate column to the right how similar or different the two tasks are." After three illustrative responses, two comparisons were presented for respondent practice. The complete cover page of the form, including the directions, is shown in Table 3.

The order of the pages in the booklet was determined from a table of random numbers, so the number of tasks listed from one page to the next could differ markedly. Four different random page orders were used, the forms being intermixed for administration to the subjects.

Table 1

Page of the Technical Task Inventory, Form C, Containing all Tasks

REPAIRING MALFUNCTIONING PARTS/EQUIPMENT IN SHOP											
	VERY SIMILAR		MODERATELY SIMILAR				MODERATELY DIFFERENT			VERY DIFFERENT	
	1	2	3	4	5	6	7	8	9	10	11
INSTRUCTING OTHERS IN THE MAINTENANCE OF AVIONIC EQUIPMENTS	—	—	—	—	—	—	—	—	—	—	—
INSTRUCTING OTHERS IN THE INSPECTION OF AVIONIC EQUIPMENTS	—	—	—	—	—	—	—	—	—	—	—
USING SAFETY PRECAUTIONS ON EQUIPMENT	—	—	—	—	—	—	—	—	—	—	—
FOLLOWING BLOCK DIAGRAMS FOR AVIONIC EQUIPMENTS	—	—	—	—	—	—	—	—	—	—	—
SUPERVISING MAINTENANCE OF AVIONIC EQUIPMENTS	—	—	—	—	—	—	—	—	—	—	—
KNOWING RELATIONSHIP OF AVIONIC EQUIPMENTS TO OTHER RELATED EQUIPMENT	—	—	—	—	—	—	—	—	—	—	—
PERFORMING INFILIGHT MAINTENANCE ON AVIONIC EQUIPMENTS	—	—	—	—	—	—	—	—	—	—	—
USING ASD CATALOG AND SECTION R ALLOWANCE LIST FOR REPLACEMENT PARTS	—	—	—	—	—	—	—	—	—	—	—
USING INSPECTION AND OPERATION MANUALS	—	—	—	—	—	—	—	—	—	—	—
PERFORMING MAJOR INSPECTIONS OF AVIONIC EQUIPMENTS	—	—	—	—	—	—	—	—	—	—	—
MAKING OUT REPORTS (FAILURE, ETC.)	—	—	—	—	—	—	—	—	—	—	—
OPERATING SPCLIALIZED TEST EQUIPMENT FOR DETERMINING MALFUNCTIONS IN AVIONIC EQUIPMENTS	—	—	—	—	—	—	—	—	—	—	—
USING MAINTENANCE MANUALS	—	—	—	—	—	—	—	—	—	—	—
OPERATING AVIONIC EQUIPMENTS	—	—	—	—	—	—	—	—	—	—	—
ANALYZING COMPLEX CIRCUITRY IN AVIONIC EQUIPMENTS	—	—	—	—	—	—	—	—	—	—	—
SUPERVISING OPERATION OF AVIONIC EQUIPMENTS	—	—	—	—	—	—	—	—	—	—	—
OPERATING STANDARD TEST EQUIPMENT FOR DETERMINING MALFUNCTIONS IN AVIONIC EQUIPMENTS	—	—	—	—	—	—	—	—	—	—	—
SUPERVISING INSPECTION OF AVIONIC EQUIPMENTS	—	—	—	—	—	—	—	—	—	—	—
ANALYZING STANDARD CIRCUITRY IN AVIONIC EQUIPMENTS	—	—	—	—	—	—	—	—	—	—	—
USING SCHEMATICS FOR COMPLEX CIRCUITS IN AVIONIC EQUIPMENTS	—	—	—	—	—	—	—	—	—	—	—
EMPLOYING ELECTRONIC PRINCIPLES INVOLVED IN THE MAINTENANCE OF AVIONIC EQUIPMENTS	—	—	—	—	—	—	—	—	—	—	—
KEEPING RECORD OF MAINTENANCE USAGE DATA	—	—	—	—	—	—	—	—	—	—	—
INSTRUCTING OTHERS IN THE OPERATION OF AVIONIC EQUIPMENTS	—	—	—	—	—	—	—	—	—	—	—
USING PROPER SAFETY PRECAUTIONS FOR SELF	—	—	—	—	—	—	—	—	—	—	—
ASSIGNING DUTIES TO PERSONNEL	—	—	—	—	—	—	—	—	—	—	—
STANDING WATCH	—	—	—	—	—	—	—	—	—	—	—
USING SCHEMATICS FOR STANDARD CIRCUITS IN AVIONIC EQUIPMENTS	—	—	—	—	—	—	—	—	—	—	—
TROUBLESHOOTING/ISOLATING MALFUNCTIONS IN AVIONIC EQUIPMENTS	—	—	—	—	—	—	—	—	—	—	—

Table 2

Sample Page of the Technical Task Inventory, Form C

	VERY SIMILAR		MODERATELY SIMILAR			6	MODERATELY DIFFERENT			VERY DIFFERENT	
	1	2	3	4	5		7	8	9	10	11
INSTRUCTING OTHERS IN THE MAINTENANCE OF AVIONIC EQUIPMENTS											
SUPERVISING MAINTENANCE OF AVIONIC EQUIPMENTS											
MAKING OUT REPORTS (FAILURE, ETC.)											
USING SCHEMATICS FOR STANDARD CIRCUITS IN AVIONIC EQUIPMENTS											
INSTRUCTING OTHERS IN THE OPERATION OF AVIONIC EQUIPMENTS											
EMPLOYING ELECTRONIC PRINCIPLES INVOLVED IN THE MAINTENANCE OF AVIONIC EQUIPMENTS											
OPERATING SPECIALIZED TEST EQUIPMENT FOR DETERMINING MALFUNCTIONS IN AVIONIC EQUIPMENTS											
ANALYZING STANDARD CIRCUITRY IN AVIONIC EQUIPMENTS											
PERFORMING MAJOR INSPECTIONS OF AVIONIC EQUIPMENTS											
INSTRUCTING OTHERS IN THE INSPECTION OF AVIONIC EQUIPMENTS											
USING PROPER SAFETY PRECAUTIONS FOR SELF											
OPERATING AVIONIC EQUIPMENTS											
KEEPING RECORD OF MAINTENANCE USAGE DATA											
SUPERVISING INSPECTION OF AVIONIC EQUIPMENTS											
ASSIGNING DUTIES TO PERSONNEL											
TROUBLESHOOTING/ISOLATING MALFUNCTIONS IN AVIONIC EQUIPMENTS											
USING MAINTENANCE MANUALS											
FOLLOWING BLOCK DIAGRAMS FOR AVIONIC EQUIPMENTS											
OPERATING STANDARD TEST EQUIPMENT FOR DETERMINING MALFUNCTIONS IN AVIONIC EQUIPMENTS											

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Table 3

Cover Page of the Technical Task Inventory, Form C

Form C

Name _____ Today's Date _____

TECHNICAL TASK INVENTORY

The purpose of this questionnaire is to compare various tasks performed by AT's in the Fleet.

One task is shown at the top of each page. Below it is a list of other tasks. Beside each task in the list is a scale running from very similar to very different. You should compare each task in the list with the one at the top of the page and indicate by a check in the appropriate column to the right how similar or different the two tasks are. There are no "right" or "wrong" answers to this Inventory; your best judgments of similarity are the only "right" answers.

Before you begin, open the booklet and look over the pages briefly to get an idea of what tasks are included. Notice that the pages have different numbers of tasks listed. Then start working at the beginning of the booklet. Try to vary your check marks so that some appear in all eleven columns. Do not hesitate to use the extreme responses numbered 1 and 11, if you feel any comparison deserves one of them.

EXAMPLE

DRIVING AND OPERATING NC-5

	VERY SIMILAR		MODERATELY SIMILAR				MODERATELY DIFFERENT			VERY DIFFERENT	
	1	2	3	4	5	6	7	8	9	10	11
FUELING PLANES	—	—	✓	—	—	—	—	—	—	—	—
TESTING TUBES	—	—	—	—	✓	—	—	—	—	—	—
SOLVING CIRCUIT EQUATIONS	—	—	—	—	—	—	—	—	—	—	✓
PERFORMING PREFLIGHT INSPECTIONS OF AVIONIC EQUIPMENTS	—	—	—	—	—	—	—	—	—	—	—
USING MAINTENANCE MANUALS	—	—	—	—	—	—	—	—	—	—	—

The first check means that the person completing the Inventory thinks that "fueling planes" is moderately similar (to the degree indicated by a "3") to "driving and operating NC-5." The second check means that the person answering feels that "testing tubes" is moderately similar (to the degree indicated by a "5") to "driving and operating NC-5." According to the check on the third line, "solving circuit equations" is very different from "driving and operating NC-5." You may or may not agree with this person. Try filling in the last two lines yourself.

WHEN YOU HAVE FINISHED, CHECK BACK TO MAKE CERTAIN YOU HAVE PLACED A CHECK NEXT TO EACH TASK IN THE LIST ON EVERY PAGE.

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Subjects

The subjects used in this study were the same as those of the previous multidimensional analytic study. There were 31 chief petty officers and 34 petty officers, first class, in the Naval aviation electronics technician (AT) rating. The squadrons to which the raters were assigned and their locations are presented in Table 4, which is repeated from the earlier report. The subjects' military experience in electronics or electrical work averaged 11.2 years. They had been AT's for an average of 8.3 years and had been assigned as an AT to an average of 3.8 squadrons.

Administration

Form C of the Technical Task Inventory was administered to the subjects in the same group sessions as Form S of the Inventory used in the earlier study. Form C was completed first, followed by Form S. The last booklet the subjects completed was the Technical Circuit Inventory, another multidimensional scaling form employing equipment as stimuli rather than tasks. The analysis of this third form will be presented in a later report.

A brief, general description of the research project was given by the administrator at the beginning of the session. A short break was permitted after the second form was completed. A few biographical facts were requested on a sheet given the subjects after the break. No time limits were imposed, but almost all the subjects completed the three booklets before the end of the scheduled three hours.

Table 4

Numbers of Subjects by Location and Squadron

<u>Location</u>	<u>Squadron</u>	<u>Number</u>
Norfolk	FAETULANT	29
	HS 3	2
	HS 7	2
	VP 24	2
	VP 56	3
	VRC 40	2
	VRF 31	1
	VS 26	2
	VU 6	3
Oceana	VA 42	2
	VA 43	10
	VA 75	1
	VF 101 Det. A	5
	VU 2	1
		<u>65</u>

As mentioned in the previous report no difficulty was encountered in achieving understanding by the subjects of what they were to do. Almost no explanation was required outside of the directions on the booklets; thus the forms were essentially self-administering.

Although the supervisors were able to accomplish the rating easily, several of them said informally that they did not see what specific purposes analysis of the data would serve. Some also mentioned that their concept of the similarity scale might have been altered as they worked through the first form, the analysis of which is reported here.

CHAPTER III

THE MULTIDIMENSIONAL SCALING ANALYSIS

In multidimensional scaling analysis, the scaled values associated with the subjects' similarity estimates are viewed as measures of the psychological distances between the stimulus pairs. In this study, the category widths on the similarity scale used were not explicitly stated for the judges either in the directions for the Technical Task Inventory or in the labeling of the scale itself. However, it seemed reasonable to assume that the judges perceived the scale category widths as equal; this assumption considerably simplified the required computations and probably introduced no gross distortions into the dimensional structure.

Under the assumption of equal category widths, it was possible to use the method of equal appearing intervals to obtain the inter-task distances. In this method the median judgment on the scale is taken as the scale value of the stimulus. In the present application, the median judgment on the similarity scale with regard to each task pair was calculated to be the scale value for that pair; the scale value, i. e., the median, was then viewed as the relative psychological distance between those two tasks. For each of the 406 task pairs of Form C of the Technical Task Inventory, the median of the 65 values checked by the subjects is presented in Table 5.

Table 5

Relative Inter-Task Distances, Form C of Technical Task Inventory
(Obtained from group of 65 subjects)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
1	----	3.40	2.91	6.50	4.47	10.18	5.70	3.95	3.67	3.58	4.03	3.25	1.78	4.75	6.11	3.50	7.36	3.90	4.48	4.00	3.25	5.25	1.61	8.72	2.83	4.12	7.21	2.56	3.61
2		----	0.88	8.39	4.58	10.27	5.13	3.68	4.73	4.31	3.88	3.31	2.25	5.13	6.21	2.42	8.21	3.60	5.83	4.65	4.41	4.72	1.97	8.75	2.91	4.77	9.02	1.85	4.22
3			----	8.45	4.09	10.19	6.32	4.54	4.60	4.62	4.41	3.83	2.54	5.17	4.77	2.86	8.57	3.55	5.38	5.63	5.25	5.19	2.46	9.29	1.52	4.63	7.83	1.83	4.00
4				----	4.23	10.10	9.04	6.38	7.57	8.69	8.21	8.85	8.64	9.11	8.23	9.31	2.50	2.88	9.02	8.36	7.10	8.30	8.95	8.50	6.23	8.00	2.43	8.19	7.17
5					----	9.96	4.71	3.10	4.20	4.91	5.83	3.75	5.21	4.27	4.21	4.94	6.10	0.90	4.44	5.25	5.00	4.58	5.08	7.92	2.93	2.83	5.57	4.27	3.58
6						----	8.14	8.00	4.79	9.11	8.75	9.27	9.80	8.36	8.40	9.90	5.50	8.08	7.95	3.25	6.50	6.75	9.65	3.77	9.39	8.25	8.50	10.05	8.75
7							----	2.72	2.22	4.42	3.46	4.38	4.55	2.77	1.00	3.95	8.13	4.55	1.81	2.56	2.32	2.03	4.68	4.81	5.32	4.38	7.61	4.32	4.50
8								----	2.82	2.33	3.68	3.61	3.65	3.64	2.96	4.06	8.67	4.75	2.68	4.21	3.79	2.94	3.05	7.42	3.95	3.31	7.08	4.23	3.45
9									----	3.10	3.10	2.88	3.69	2.95	2.46	4.50	9.05	4.89	2.78	0.67	2.96	2.88	4.17	8.15	4.95	3.39	9.04	5.88	7.57
10										----	4.71	3.79	1.98	5.57	4.68	4.37	9.11	4.18	2.68	4.05	4.50	5.10	1.35	8.81	3.65	4.17	8.68	3.41	2.58
11											----	3.08	2.10	1.80	2.08	2.88	7.06	3.13	4.29	3.63	1.39	2.69	2.72	6.92	2.96	4.53	7.28	2.35	3.06
12												----	2.77	4.59	4.21	1.61	8.56	4.81	2.30	4.63	4.94	5.42	2.43	9.32	3.05	4.32	8.89	2.95	3.95
13													----	4.77	4.50	2.70	8.88	3.38	4.36	3.94	3.58	4.77	1.43	7.36	1.92	3.65	8.14	1.42	2.97
14														----	1.72	4.23	7.31	4.32	4.25	4.05	2.82	1.59	4.41	5.50	4.88	2.23	8.42	4.61	4.79
15															----	4.95	8.75	5.64	1.58	2.42	3.83	3.06	4.89	7.17	4.74	4.42	9.02	4.96	4.25
16																----	8.54	4.17	2.50	4.38	4.47	4.72	1.69	9.18	4.09	4.04	8.25	3.21	4.23
17																	----	4.68	8.68	8.00	6.05	6.71	7.56	8.75	7.32	6.79	1.44	8.06	7.94
18																		----	4.79	6.10	5.00	4.72	2.32	9.18	1.60	3.75	6.45	2.75	1.74
19																			----	2.45	4.59	4.70	4.41	7.80	6.00	3.70	8.50	5.75	4.85
20																				----	2.97	3.33	4.50	7.19	4.91	3.94	9.39	6.28	6.42
21																					----	1.77	3.17	2.54	3.35	3.59	4.85	3.47	4.03
22																						----	4.58	3.21	4.37	1.97	6.17	4.35	4.23
23																							----	8.36	1.25	3.21	7.05	1.64	1.25
24																								----	8.25	8.06	6.44	7.65	7.50
25																									----	3.77	7.50	0.88	2.43
26																										----	6.19	4.08	4.13
27																										----	8.90	7.88	
28																											----	2.28	
29																													

The Reliability of the Inter-Task Distance Estimates

There have been only a few reports of the reliability of the distance judgments in multidimensional scaling. Using successive intervals procedures with 20 colors as stimuli, Helm (1960) ran one subject through the experiment a second time after an interval of three weeks. The product-moment correlation coefficient between the two sets of judgments was .87. In addition, as a standard part of Helm's experimental procedure, after all the stimulus pairs had been reacted to once, the first 20 pairs were immediately readministered. Helm reported that marked changes in scale value assignments were rare. Also, he used a warm-up of 10 or so repeated estimates if part of the experiment was completed on a second day, with little change occurring in category placement of the colors.

The issue of whether the inter-stimulus distance as judged from stimulus A to stimulus B is the same as the distance as judged from B to A involves not only judgment reliability but also the question of whether the data fit the requirements of a Euclidean space model. Messick (1956a) and Schultz and Siegel (1962) found that this non-directional characteristic was present in their data, implying both judgment reliability and the presence of a model requirement.

As mentioned above, Form C of the Technical Task Inventory, used in the study described here, had nine items also appearing in Form S, which applied to the striker's job. It was possible, therefore, to compare the scale values for the distances among these nine items, first as derived from Form C and second as derived from Form S. In Form S both the A-to-B and B-to-A judgments were

made; the one which matched that included in Form C was used for the reliability determination.

The means and standard deviations of the 36 distance estimates among these nine stimuli are presented in Table 6. In general, the scale values are displaced upward (toward the "different" end of the scale) and are slightly less scattered when the distances are estimated for a second time. However, the correlation coefficient between the two sets of scale values is .94. It would appear, therefore, that the ranking of the distance judgments remained the same but that the entire reference scale shifted as the men worked through more ratings. When these findings are tied in with the facts that (1) some of the men said they thought this had happened to them and (2) the A-to-B and B-to-A estimates derived from Form S (the second form administered) were almost identical, there is a strong suggestion that it takes the judges a while to settle the type of judgment here involved into a stable frame of reference. To eliminate any distortions introduced by this tendency, it would probably be wise, whenever possible, to give the judges a number of practice trials before they are asked to make ratings which are used in analyses. It will be recalled that two practice ratings were provided on the cover page of Form C of the Technical Task Inventory; apparently more than this number are required. Also, since four random page arrangements were employed, a particular task pair appeared in different parts of the booklet for various subject subgroups. Any pronounced effect resulting from an item's position should thus have been minimized when all the subjects were pooled for the analysis. The

results discussed above appeared in spite of this precaution. The varied page arrangement had also been used with Form S of the Technical Task Inventory, to reduce the position effect.

Table 6

Means and Standard Deviations of Inter-Task Distances Judged on Two Different Forms of the Technical Task Inventory at the Same Administration

	<u>Form C</u> <u>(N = 36)</u>	<u>Form S</u> <u>(N = 36)</u>
Mean	5.51	6.18
S.D.	2.46	2.29

It should be mentioned that the determination of the proper additive constant to set the obtained scale values on a ratio scale will, to some extent, correct for the problem discussed here. However, if the reference scale is actually shifting from one rating to the next, this adjustment procedure cannot be expected to take care of the difficulty entirely.

The Dimensionality Analysis

Starting with the scaled inter-task distances shown in Table 5, the usual multidimensional scaling procedures were followed. First, the Messick-Abelson (1956) general solution to the additive constant problem was applied to the data in order to obtain a value which could be added to the original scaled distances in order to achieve a ratio, rather than merely an interval, scale as required by the

analytical model. This constant was found to be + 3.10. The smallest judged distance in Table 5 is 0.67; accordingly the smallest corrected inter-task difference became + 3.77.

The matrix of corrected scale values was converted to a matrix, B^* , of scalar products of the vectors to points with an origin at the centroid of the stimuli. The B^* matrix is given in Appendix A of this report.

The B^* matrix was factored by the method of principal components to produce the matrix, F , presented in Appendix B. The rank of matrix F is nine. The matrix of residuals, after extraction of the nine dimensions from the matrix B^* is given in Appendix C.

The nine axes of matrix F were rotated to orthogonal, simple structure as tested by the normal equamax criterion, an analytical solution to the rotation problem developed by Saunders (1962). The transformation matrix is presented in Table 7 and the final matrix of projections of the stimuli (tasks) on the rotated axes is presented in Table 8.

Interpretation of Dimensions

Dimension I. The tasks with the highest projections (loadings) on the first dimension are shown in Table 9. The positive end of this dimension appears to involve the maintenance and troubleshooting of avionic equipments, while the negative end involves the routine use of reference materials and record keeping. Since the positive direction calls for problem solving as related to the diagnosis of malfunctions in electronic equipment and the maintenance of electronic equipment,

Table 7
Transformation Matrix

	I	II	III	IV	V	VI	VII	VIII	IX
I	- 0.52	- 0.41	- 0.34	0.00	- 0.13	0.46	0.46	0.05	0.08
II	0.26	- 0.43	0.40	- 0.52	- 0.50	0.17	- 0.07	0.06	- 0.18
III	0.12	- 0.03	0.03	0.61	- 0.59	- 0.30	0.24	0.34	- 0.08
IV	- 0.34	0.12	0.64	0.36	0.00	0.27	0.02	- 0.42	- 0.28
V	- 0.49	0.09	- 0.06	- 0.11	0.02	- 0.06	- 0.40	0.54	- 0.54
VI	0.06	0.35	- 0.41	0.06	- 0.51	0.40	- 0.44	- 0.29	0.00
VII	0.38	- 0.43	- 0.03	0.44	0.34	0.44	- 0.34	0.21	- 0.08
VIII	- 0.19	0.21	0.37	0.00	- 0.07	0.24	- 0.18	0.44	0.71
IX	- 0.34	- 0.51	- 0.03	0.12	- 0.10	- 0.43	- 0.48	- 0.31	0.29

Table 8

Final Matrix of Projections of Tasks on Dimensions

<u>Task No.</u>	<u>Dimension Number</u>							
	I	II	III	IV	V	VI	VII	VIII
1	0.64	4.01	- 1.47	- 0.44	0.10	- 0.76	- 0.27	0.12
2	0.30	1.09	- 0.86	0.09	0.28	- 4.58	- 1.52	0.18
3	0.03	1.30	- 0.95	0.37	0.97	- 4.38	- 1.37	- 0.31
4	- 5.40	1.06	- 2.34	1.35	2.98	2.29	4.27	- 2.02
5	- 2.46	0.20	0.50	1.26	2.68	- 0.54	0.51	- 3.36
6	0.05	- 7.30	- 2.99	- 4.71	- 1.61	3.00	2.43	1.60
7	- 0.02	- 1.33	3.41	- 0.09	- 2.00	1.27	- 1.08	- 0.61
8	0.85	0.56	1.10	- 0.29	- 0.33	0.43	- 0.05	- 3.22
9	0.20	0.42	1.25	- 5.50	- 0.08	0.20	- 0.16	- 0.89
10	4.42	1.41	- 0.29	- 0.26	0.64	0.72	- 0.53	- 2.00
11	0.21	1.26	2.27	0.35	- 0.49	0.17	- 0.35	3.56
12	0.78	0.86	0.61	- 0.53	0.94	- 0.93	- 3.77	- 0.18
13	2.47	2.38	- 0.04	0.28	- 0.83	- 1.80	- 0.55	0.49
14	- 0.66	- 0.59	2.99	- 0.30	- 0.60	- 0.05	0.30	1.52
15	0.02	- 0.68	4.93	- 1.04	0.20	1.04	- 0.35	- 0.31
16	0.30	0.94	0.01	0.40	- 0.02	- 1.24	- 4.75	0.71
17	- 4.88	- 2.07	- 4.69	1.10	2.36	3.37	1.87	2.73
18	- 0.52	- 0.00	- 0.71	1.59	4.43	- 0.28	0.97	0.48
19	1.12	- 0.74	1.92	- 1.32	0.01	2.38	- 3.64	- 1.89
20	1.08	- 1.33	0.63	- 5.11	- 0.48	0.63	- 0.32	0.40
21	- 0.34	0.37	- 0.00	- 0.01	- 3.40	0.78	1.44	1.50
22	- 0.52	- 1.58	1.01	0.03	- 2.32	- 0.03	1.32	0.21
23	2.81	1.97	- 1.44	1.34	0.26	- 0.81	- 1.52	0.99
24	- 1.22	- 4.58	0.24	0.99	- 6.57	1.04	3.73	0.23
25	0.85	1.52	- 0.36	1.08	1.72	- 2.63	1.31	0.50
26	0.36	0.42	- 0.93	- 0.12	0.79	0.53	- 0.15	- 0.92
27	- 5.12	0.22	- 4.71	3.14	- 1.55	3.80	1.76	- 0.71
28	1.63	0.96	0.51	2.35	0.43	- 3.35	- 0.04	1.25
29	3.04	- 0.73	0.40	3.98	1.49	- 0.28	0.49	- 0.04

Table 9

Tasks with Highest Projections on Dimension I

<u>Task No.</u>	<u>Loading</u>	<u>Task</u>
10	+ 4.42	Performing inflight maintenance on avionic equipments
29	+ 3.04	Following block diagrams for avionic equipments
23	+ 2.81	Troubleshooting/isolating malfunctions in avionic equipments
13	+ 2.47	Employing electronic principles involved in the maintenance of avionic equipments
5	- 2.46	Using inspection and operation manuals
17	- 4.88	Making out reports (failure, etc.)
27	- 5.12	Keeping record of maintenance usage data
4	- 5.40	Using ASO catalog and Section R allowance list for replacement parts

the name assigned to this dimension is "electro-cognition."

Dimension II. The two tasks with the highest positive loadings on this dimension, as seen in Table 10, relate to aspects of equipment repair in the shop. Since shop work represents the central and most complex repair process, this dimension is designated "electro-repair (complex)" to differentiate it from the "electro-repair (simple)" dimension extracted in the journeyman level study.

Dimension III. Three of the four tasks with positive loadings in Table 11 involve instructional activities. There is little doubt that the third dimension is "instruction."

Dimension IV. Table 12 presents the tasks with the highest loadings on the fourth dimension. Although the positive direction on the dimension involves some kind of ability in understanding diagrams and circuitry, the precise nature of that portion of the axis is not very clear. The negative direction obviously is a safety factor. This dimension is called "electro-safety."

Dimension V. The tasks with negative loadings listed in Table 13 provide the basis for naming this dimension. These four tasks are all essentially the management of personnel involved in serving in a maintenance capacity. Therefore, the name "personnel relationships" was chosen for the fifth dimension.

Dimension VI. The group of tasks associated with negatively oriented loadings presented in Table 14 suggest that dimension VI relates to the understanding of the principles of electronic circuitry. The tasks with the high positive loadings are generally more simple, routine duties. This dimension is assumed

Table 10

Tasks with Highest Projections on Dimension II

<u>Task No.</u>	<u>Loading</u>	<u>Task</u>
1	+ 4. 01	Repairing malfunctioning parts/equipment in shop
13	+ 2. 38	Employing electronic principles involved in the maintenance of avionic equipments
17	- 2. 07	Making out reports (failure, etc.)
24	- 4. 58	Assigning duties to personnel
6	- 7. 30	Standing watch

Table 11

Tasks with Highest Projections on Dimension III

<u>Task No.</u>	<u>Loading</u>	<u>Task</u>
15	+ 4.93	Instructing others in the operation of avionic equipments
7	+ 3.41	Supervising operation of avionic equipments
14	+ 2.99	Instructing others in the inspection of avionic equipments
11	+ 2.27	Instructing others in the maintenance of avionic equipments
4	- 2.34	Using ASO catalog and Section R allowance list for replacement parts
6	- 2.99	Standing watch
17	- 4.69	Making out reports (failure, etc.)
27	- 4.71	Keeping record of maintenance usage data

Table 12

Tasks with Highest Projections on Dimension IV

<u>Task No.</u>	<u>Loading</u>	<u>Task</u>
29	+ 3.98	Following block diagrams for avionic equipments
27	+ 3.14	Keeping record of maintenance usage data
28	+ 2.35	Analyzing standard circuitry in avionic equipments
6	- 4.71	Standing watch
20	- 5.11	Using proper safety precautions for self
9	- 5.50	Using safety precautions on equipment

Table 13

Tasks with Highest Projections on Dimension V

<u>Task No.</u>	<u>Loading</u>	<u>Task</u>
18	+ 4.43	Using maintenance manuals
4	+ 2.98	Using ASO catalog and Section R allowance list for replacement parts
5	+ 2.68	Using inspection and operation manuals
17	+ 2.36	Making out reports (failure, etc.)
7	- 2.00	Supervising operation of avionic equipments
22	- 2.32	Supervising inspection of avionic equipments
21	- 3.40	Supervising maintenance of avionic equipments
24	- 6.57	Assigning duties to personnel

Table 14

Tasks with Highest Projections on Dimension VI

<u>Task No.</u>	<u>Loading</u>	<u>Task</u>
27	+ 3. 80	Keeping record of maintenance usage data
17	+ 3. 37	Making out reports (failure, etc.)
6	+ 3. 00	Standing watch
19	+ 2. 38	Operating avionic equipments
4	+ 2. 29	Using ASO catalog and Section R allowance list for replacement parts
25	- 2. 63	Using schematics for standard circuits in avionic equipments
28	- 3. 35	Analyzing standard circuitry in avionic equipments
3	- 4. 38	Using schematics for complex circuits in avionic equipments
2	- 4. 58	Analyzing complex circuitry in avionic equipments

to be the "electro-comprehension" dimension found in the study of striker and third class AT's. An alternate name in both studies could be "electronic circuit analysis."

Dimension VII. Table 15 contains the six tasks with the highest loadings on the seventh dimension extracted. The thread running through the three tasks with negative values is clearly operating various equipment and the highest loading is associated with the operation of more complex equipment. Therefore, this dimension is labeled "equipment operation (complex)."

Dimension VIII. Although this dimension does not appear to be as clear as the others, in terms of the task loadings presented in Table 16, the negative orientation of the axis seems to involve the use of supporting reference materials. This dimension is, therefore, tentatively named "using reference materials."

Dimension IX. As can be seen from the tasks listed in Table 17, the negative direction of this dimension relates to various aspects of inspecting avionic equipment. The emphasis here seems to be on the more important inspection activities, rather than on the simpler, more routine inspections. As a result, the name selected for this dimension is "equipment inspection (complex)."

Comparison of Two Job Levels within the Aviation Electronics Technician Rating

Since the previous study by Schultz and Siegel (1962) extracted the factors of the aviation electronic technician job at the level of strikers and petty officers, third class, a comparison can now be made between the journeyman level and the

Table 15

Tasks with Highest Projections on Dimension VII

<u>Task No.</u>	<u>Loading</u>	<u>Task</u>
4	+ 4.27	Using ASO catalog and Section R allowance list for replacement parts
24	+ 3.73	Assigning duties to personnel
6	+ 2.43	Standing watch
19	- 3.64	Operating avionic equipments
12	- 3.77	Operating standard test equipment for determining malfunctions in avionic equipments
16	- 4.75	Operating specialized test equipment for determining malfunctions in avionic equipments

Table 16

Tasks with Highest Projections on Dimension VIII

<u>Task No.</u>	<u>Loading</u>	<u>Task</u>
11	+ 3.56	Instructing others in the maintenance of avionic equipments
17	+ 2.73	Making out reports (failure, etc.)
4	- 2.02	Using ASO catalog and Section R allowance list for replacement parts
8	- 3.22	Knowing relationship of avionic equipments to other related equipment
5	- 3.36	Using inspection and operation manuals

Table 17

Tasks with Highest Projections on Dimension LX

<u>Task No.</u>	<u>Loading</u>	<u>Task</u>
4	+ 3.48	Using ASO catalog and Section R allowance list for replacement parts
22	- 2.93	Supervising inspection of avionic equipments
14	- 3.43	Instructing others in the inspection of avionic equipments
26	- 4.46	Performing major inspections of avionic equipments

supervisory level AT job in terms of the underlying dimensions seen by the supervisors as constituting each job.

Nine meaningful dimensions resulted from the examination of the chief petty officer's job, while only four were found in the study of strikers. Thus, it can be concluded that the supervisory personnel's job is based on a more heterogeneous substrate than is that of the striker. This is not merely a matter of performing more tasks within the same dimensional framework but of serving more functions of a basically different kind. The additional performance dimensions of the chief petty officer's job are electro-cognition (maintenance-troubleshooting), instruction, personnel relationships, and using reference materials.

The four job dimensions at the journeyman level are also present at the higher level. Electro-comprehension and electro-safety appear to be essentially similar in character in each case. But as one moves from the lower to the higher level job, routine equipment operation and inspection breaks into two independent dimensions, each involving more complex requirements. For example, the inspection portion of the strikers' dimension is characterized by the performance of preflight and postflight inspections of avionic equipment, while the chief petty officers' dimension is characterized by the performance of major inspections. In addition, the electro-repair dimension differs in complexity at the two job levels. For the striker it consists primarily of removing malfunctioning parts and equipment from planes and replacing them after repair; for the chief petty officer, on the other hand, this dimension refers to repair work on malfunctioning

parts and equipment in the shop, involving knowledge of appropriate electronic principles.

Thus, in general, the job of chief petty officer and petty officer, first class, in the aviation electronics technician rating is seen by the supervisors, on the basis of this research, to encompass all the activities that are performed by strikers and petty officers, third class, in the rating but at a more complex level and, in addition, to include several functions which are not performed by strikers.

Discussion

The dimensional organization of the AT rating defined by the results of the present research seems reasonable, both in its own right and in comparison with the results of the journeyman level study. The nine dimensions describe obviously important parts of the AT supervisory job. Men at the chief petty officer level should know the basic technical skills such as operation, inspection, and repair, yet have a deeper understanding of the basic principles and possess a higher skill level than would be expected of a less experienced technician. In addition, it is apparent that a supervisor is called upon to instruct and serve other functions involving personnel relationships.

The characteristics of the dimensions extracted appear to lend themselves to the construction of unidimensionally scaled instruments for measuring each dimension separately. Since several of the dimensions represent higher levels of factors also present in the striker and petty officer, third class, AT job, it may be possible to develop single scales in these cases to cover the whole range of

activities encompassing the two job levels. In electro-safety, there are probably minor differences between the two job levels, so the same unidimensional scale would be applicable. A methodology for constructing job task performance instruments which meet the Thurstone and/or Guttman scalability requirements is available from previous research (Schultz and Siegel, 1961; Siegel and Schultz, 1962).

It might be argued that, for purposes of evaluating the job performance of individual chief petty officers, the perceptions of their superiors, i. e., commissioned officers or warrant officers, should be analyzed as the basis for selecting the dimensions along which the evaluations should be made. However, good personnel practice would suggest acceptance of the job criterion by both the worker--in this case, the chief petty officer--and his superior--the commissioned officer or the warrant officer. Acceptance will very likely be enhanced if both parties perceive the job as involving the same dimensions. Thus, the current study may be viewed, in part, as one step in the development of evaluative instruments for non-commissioned AT supervisors.

Two important points regarding multidimensional scaling procedures should be kept in mind in evaluating findings resulting from their application. First, the outcomes, i. e., the dimensions, are initially determined by the form and adequacy of the input data. In the present investigation the goal was to provide the judges with a group of tasks that would include all the important work activities of aviation electronics technicians at the chief petty officer and petty officer, first class, level.

As a result, the dimensions are defined in terms of work activities, rather than other possible types of input information, such as equipment used, equipment worked on, or worker requirements.

Second, the clarity and validity of the resultant dimensional structure in some instances may depend upon the appropriateness of certain decisions about technical matters which are made as the analysis is proceeding. The choice of method used to scale the stimulus pair judgments and the issue of the advisability of a transformation of the scaled inter-stimulus distances (Helm, Messick, and Tucker, 1961) are two examples of such matters which have been previously mentioned.

In both the earlier study of the striker's job and in the current study, several dimensional spaces appeared to fit the data reasonably well from the psychometric viewpoint. In the report of the first study (Schultz and Siegel, 1962) it was mentioned that application of the Messick-Abelson solution for the additive constant led initially to eight, instead of the eventually chosen four dimensions. In the present work, in addition to the analysis described here, a four dimensional solution was arbitrarily imposed on the data. The resultant dimensionality appeared to possess psychometric consistency and reasonableness. In both studies the ultimate criterion used in selecting a final solution was the over-all meaningfulness, precision, and clarity of the dimensions extracted, as manifested in the tasks with the highest loadings on the dimensions. In each study, however, a solution involving a different number of dimensions could have been justified on the basis of the empirical data and would have produced defensible conclusions.

CHAPTER IV

SUMMARY AND CONCLUSIONS

Summary

The study described in this report represents a second application of multidimensional scaling methods in the area of job performance criterion development. The results of the first application of the methods to job related stimuli (Schultz and Siegel, 1962) suggested that the job performance of Naval aviation electronics technicians at the striker and petty officer, third class, level comprised four basic dimensions. Since a contention that multidimensional scaling can be useful for analyzing a job task constellation was supported, it seemed desirable to carry out a further study, this time applying the techniques, for comparative purposes, at a different job level.

The objectives of this study, therefore, paralleled those of the earlier program. They were to: (1) explore further the feasibility of applying standard multidimensional scaling procedures to a job task constellation, (2) investigate more fully specific methods for applying these techniques in the work oriented situation, (3) determine the number and the nature of the dimensions of the job of the Naval aviation electronics technician (AT) supervisor, and (4) compare the dimensional structure of the aviation electronics technician's job at the supervisory level with that of the same rating at the journeyman level.

The procedures followed in the present work were very similar to those of

the previous investigation. The same subjects were involved and there was communality among the forms used. Initially a list of tasks which were thought to include all the job activities typically performed by Naval aviation electronics technicians was submitted to a group of men experienced in the rating. It was the consensus of this group that 29 of the listed tasks constituted the job of chief petty officer and petty officer, first class. Of the 29 tasks, 9 were also included in the group comprising the striker's job, as revealed in the previous study. A number of the simpler tasks were designated as being done only by strikers and the generally more complex tasks only by chief petty officers.

A booklet was prepared, so that all possible pairs of the 29 tasks could be rated along an eleven-point similarity scale. The analysis, by the method of equal appearing intervals, of the data resulting from administration of this booklet to a group of chief and first class petty officers in the AT rating produced scale values for the task pairs.

Taking the scale value for each task pair as the psychological distance between that pair, multidimensional procedures that have been frequently used were followed. The Messick-Abelson solution to the additive constant problem was first applied, in order to obtain a value which could be added to the scaled distance so that they could refer to a true zero point. A matrix of scalar products was then computed from the corrected scale values and factored by the method of principal components. The factor matrix was rotated to orthogonal simple structure according to the equamax criterion.

A spatial structure of nine dimensions was determined as underlying the distance system defined by the inter-task data. The nine dimensions were named "electro-cognition," "electro-repair (complex)," "instruction," "electro-safety," "personnel relationships," "electro-comprehension," "equipment operation (complex)," "using reference materials," and "equipment inspection (complex)." It was pointed out that all four dimensions found in the earlier analysis of the AT striker's job were represented among these nine dimensions. Two of the common dimensions were essentially similar at the two job levels, while the other two were characterized by more complex activities at the supervisory level. In addition, the chief petty officer's job includes several functions not performed by strikers.

In view of several technical problems that are involved, the results of both the current study and the earlier study should be looked upon as subject to further verification, refinement, and clarification. Nevertheless, the general picture of the two job levels in the AT rating that they define appears to be reasonable and useful. In particular, the characteristics of the extracted dimensions would appear to make it possible to develop unidimensional, scaled criterion instruments for the separate dimensions. Such measures could be applied in the evaluation of the job performance of individuals in each of the independent kinds of job performance behavior.

Conclusions

Further evidence is provided by the results of the research described in this report that it is feasible and fruitful to apply multidimensional scaling

techniques to Naval job performance. The methods developed generate the appropriate basic data required by the multidimensional models.

The following conclusions are indicated with regard to the specific job studied:

1. The work performed by chief petty officer and petty officer, first class, aviation electronics technicians is perceived by men at that level in the rating as involving nine basic dimensions. The dimensions are tentatively named "electro-cognition," "electro-repair (complex)," "instruction," "electro-safety," "personnel relationships," "electro-comprehension," "equipment operation (complex)," "using reference materials," and "equipment inspection (complex)."
2. The characteristics of the nine extracted dimensions would appear to make it possible to develop unidimensional scales for the evaluation of individual technicians on each dimension.
3. The job of chief petty officer and petty officer, first class, in the aviation electronics technician rating encompasses all four of the basic dimensions that are represented in the striker and petty officer, third class, job. However, the supervisory personnel perform at a generally more complex level and, in addition serve several functions which are not engaged in by the journeyman level personnel.

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APPENDIX A

Appendix A presents the matrix B^*

Appendix A

Matrix β^* of Scalar Products with Origin at Centroid of Stimuli

	1	2	3	4	5	6	7	8	9	10
1	25.6703	7.0627	10.6299	5.6980	-2.4838	-28.2127	-13.2932	-1.7628	2.2341	5.2964
2	7.0627	30.6607	23.2580	-11.7304	-0.8269	-26.9164	-5.9465	2.5985	-3.0050	2.6512
3	10.6299	23.2580	31.6686	-11.9174	3.3185	-25.3463	-15.9402	-3.0952	-1.4921	0.8111
4	5.6980	-11.7304	31.6686	77.8200	25.3783	-1.0789	-22.1768	4.2364	-5.6857	-15.8021
5	-2.4838	-0.8269	3.3185	25.3783	26.6153	-24.8435	-4.6022	4.3380	-1.0201	-3.9954
6	-28.2127	-26.9164	-25.3463	-1.0789	-24.8435	94.1719	-3.4829	-4.2519	28.2792	-12.6648
7	-13.2932	-5.9465	-15.9402	-22.1768	-4.6022	-3.4829	25.1230	5.8744	10.7208	-0.9384
8	-1.7628	2.5985	-3.0952	4.2364	4.3380	-4.2519	5.8744	20.4583	5.0185	10.2548
9	2.2341	-3.0050	-1.4921	-5.6857	-1.0201	28.2792	10.7208	5.0185	24.5846	7.8431
10	5.2964	2.6512	0.8111	-15.8021	-3.9954	-12.6648	-0.9384	10.2548	7.8431	29.4991
11	-3.0170	0.5360	-2.7981	-15.4674	-16.9923	-13.5428	0.6091	-3.1899	2.6354	-6.1798
12	6.4934	8.6060	5.6433	-18.6526	3.6676	-15.5824	-1.5904	1.5378	8.2303	4.8348
13	11.9589	12.0517	10.9631	-18.9493	-10.1777	-25.0606	-5.6593	-1.5147	0.2777	12.8780
14	-4.8900	-5.4487	-5.2746	-22.5310	-0.7663	-5.4814	8.4124	0.5977	7.0710	-9.7459
15	-15.1650	-13.5955	-0.7269	-10.8553	0.9950	-4.6194	18.5509	6.2684	11.2348	-1.1077
16	5.3021	14.3384	11.7176	-23.8272	-4.7612	-23.1452	1.9588	-1.1547	-2.3373	1.0991
17	-5.1102	-11.8644	-15.4956	59.9738	7.7438	46.8600	-13.7319	-22.2724	-24.7528	-23.0261
18	-0.9412	3.6080	4.4455	31.7500	16.0210	-4.6723	-5.9739	-9.8555	-8.9007	-1.0250
19	-1.2452	-9.8896	-5.4700	-19.8738	-0.4705	0.6944	15.1461	8.1666	9.6471	12.6870
20	1.5960	-0.7328	-8.3007	-12.7750	-7.5835	40.8880	10.5046	-2.5223	19.1403	3.1543
21	0.6612	-4.8784	-11.0328	-5.1095	-11.5040	9.0044	5.8574	-5.5177	1.9168	-6.1388
22	-11.4870	-4.7086	-7.9889	-15.5205	-5.6468	9.1189	9.9311	2.5195	4.9431	-8.3319
23	11.2680	12.0040	9.9053	-24.1412	-10.6118	-24.6429	-8.1673	0.8477	-4.6005	14.3723
24	-19.5285	-17.3883	-23.4273	9.1218	-9.9228	60.9631	18.7566	-7.6180	-13.4984	-18.6817
25	5.9147	7.9326	15.8196	6.0592	5.7895	-20.2296	-12.2162	-3.9562	-9.4397	2.6331
26	-1.6646	-4.0715	-2.4760	-11.1173	7.2852	16.3285	-8.2711	1.2467	2.7941	-0.1123
27	-3.7948	-21.5926	-7.3779	60.1213	12.2357	16.3285	-8.2711	-5.0694	-24.6731	-18.1115
28	9.4082	15.6676	16.2702	-12.2119	-1.2541	-26.7588	-2.3698	-4.0367	-15.4257	6.1533
29	3.4019	1.6200	3.7094	-0.7355	4.0751	-10.0289	-3.2367	1.8562	-31.5398	11.6936

Matrix B^* of Scalar Products with Origin at Centroid of Stimuli (Con't.)

	11	12	13	14	15	16	17	18	19	20
1	-3.0170	6.4934	11.9589	-4.8900	-15.1650	5.3021	-5.1102	-0.9412	-1.2452	1.3960
2	0.5360	8.6060	12.0517	-5.4487	-13.5955	14.3384	-11.8644	3.6080	-9.8896	-0.7328
3	-2.7981	5.6433	10.9611	-5.2746	-0.7269	11.7176	-15.4956	4.4455	-5.4700	-8.3007
4	-15.4674	-18.6526	-18.9493	-22.5310	-10.8553	-23.8272	59.9738	21.7520	-1.98738	-12.7750
5	-16.9923	3.6676	-10.1777	-0.7663	0.9050	-2.7612	7.7438	16.0210	-0.4705	-7.5835
6	-13.5428	-15.5824	-25.6566	-5.4814	-4.6194	-23.1452	46.8600	-4.6723	0.6944	40.8880
7	0.6091	-1.5904	-5.6593	8.4124	18.5509	1.9588	-13.7319	-5.9739	15.1461	10.5046
8	-3.1899	1.5378	-1.5147	0.5977	6.2684	-1.1547	-22.2724	-9.8555	8.1666	-2.5223
9	-2.6354	8.2303	0.2777	7.0710	11.2348	-2.3373	-24.7528	-8.9007	9.6471	19.1403
10	-6.1792	4.8348	12.8780	-9.7459	-1.1077	1.0991	-23.0261	-1.0250	12.6870	3.1543
11	19.0839	4.2646	7.0540	10.6130	10.5228	5.9066	-5.3114	0.8565	-3.1169	0.8601
12	4.2646	27.5955	7.6037	-2.6847	1.4851	16.9462	-17.4155	-6.7595	13.8581	-2.1107
13	7.0540	7.6037	22.0285	-6.8680	-3.4594	8.4385	-23.9803	0.7410	-2.1641	0.1991
14	10.5238	1.4851	-3.4594	15.8399	15.8399	0.4443	-4.3645	-3.7438	0.6951	1.4641
15	-5.9066	16.9462	8.4385	26.1186	28.7607	-3.7690	-19.0657	-1.4775	13.1855	13.1056
16	-5.3114	-17.4155	-23.9803	-4.3645	-19.0657	-16.7559	73.4493	17.1868	-17.9973	-10.9008
17	0.8565	-6.7595	0.7410	-3.7438	-13.0838	-1.4775	17.1868	21.3994	-5.7774	-17.6472
18	-3.1169	13.8581	-2.1641	0.6951	18.0671	13.1855	-17.9973	-5.7774	29.2438	13.1812
19	0.8601	-2.1107	0.1991	1.4641	13.1056	0.2164	-10.9008	-17.6472	13.1812	27.8831
20	7.4429	-10.5299	-3.3085	3.5220	-1.6428	-6.4365	2.8603	-14.1119	-6.9542	3.5055
21	3.3102	-11.9578	-9.4167	12.5878	5.9391	-5.8145	-0.8493	-9.3392	-5.2609	3.8016
22	2.1344	8.0350	10.2781	-5.6063	-8.0036	12.2775	-10.5479	5.5388	-4.0437	-5.4037
23	-3.1719	-25.8359	-6.2037	13.5608	-0.8689	-23.6807	4.0060	-27.2054	-7.2937	-1.5132
24	1.8426	5.5493	9.0730	-8.1119	-5.6839	-0.9573	-6.8862	10.3125	-16.1102	-7.4694
25	-8.0007	-2.1654	-0.2042	10.4128	-2.3294	0.2987	-0.6079	-1.1984	3.0649	0.7245
26	-7.8119	-19.1811	-15.6332	-16.7737	-22.5426	-13.6652	62.9172	1.6140	-16.1356	-27.5329
27	7.2309	8.0887	13.3861	-4.0849	-4.7017	6.9095	-12.9384	6.1800	-11.9375	-17.4470
28	3.6461	2.0265	5.6684	-4.9839	0.4501	0.2941	-11.1225	12.0593	-3.8963	-18.2852

Matrix B^* of Scalar Products with Origin at Centroid of Stimuli (Con't.)

	21	22	23	24	25	26	27	28	29
1	0.6612	-11.4870	11.2660	-19.5285	5.9147	-1.6646	-3.7948	9.4082	3.4019
2	-4.8784	-4.7086	12.0040	-17.3883	7.9326	-4.0715	-21.5926	15.6676	1.6200
3	-11.0325	-7.9529	9.9053	-23.4273	15.8196	-2.4760	-7.3779	16.2702	3.7094
4	-5.1095	-15.5205	-24.1412	9.1226	4.0592	-11.1173	60.1213	-12.2119	-0.7355
5	-11.5040	-5.6468	-10.6118	-9.9228	5.7895	7.2852	12.2357	-1.2541	4.0751
6	9.0044	9.1189	-24.6429	60.9631	-20.2296	-5.7468	16.3285	-26.7588	-10.9289
7	5.8574	9.9311	-8.1673	18.7566	-12.2162	-3.8484	-8.2711	-2.3698	-3.2367
8	-5.5177	2.5195	0.8477	-7.6180	-3.9562	1.2467	-5.0694	-4.0387	1.8562
9	1.9168	4.9431	-4.6005	-13.4984	-9.4397	2.7941	-24.8731	-15.4257	-31.5398
10	-6.1388	-8.3319	14.3723	-18.6817	2.6331	-0.1123	-18.1115	6.1533	11.6936
11	7.4429	3.3102	2.1344	-3.1719	1.8426	-8.0007	-7.8119	7.2809	3.6461
12	-10.5299	-11.9578	8.0350	-25.8359	5.5493	-2.1654	-19.1811	8.0887	2.0265
13	-3.3085	-9.4167	10.2781	-6.2037	9.0730	-0.2042	-15.6332	13.3861	5.6684
14	3.5220	12.5878	-5.6063	13.5608	-8.1119	10.4128	-16.7737	-4.0649	-4.9839
15	-1.6428	5.9391	-8.0036	-0.8689	-5.6839	-2.3294	-22.5426	-4.7017	0.4501
16	-6.4365	-5.8145	12.2775	-23.6807	-0.9573	0.2987	-13.6652	6.9095	0.2941
17	2.8603	-0.8493	-10.5479	4.0060	-6.8862	-0.6079	62.9172	-12.9384	-11.1225
18	-14.1119	-9.3392	5.5388	-27.2054	10.3125	-1.1984	1.6140	6.1800	12.0593
19	-6.9542	-5.2609	-4.0437	-7.2937	-16.1102	3.0649	-16.1356	-11.9375	-3.8963
20	3.5055	3.8016	-5.4037	-1.5132	-7.4694	0.7245	-27.5329	-17.4470	-18.2852
21	15.9312	6.6343	-2.1606	29.5322	-2.1718	-2.8498	12.8744	-1.0228	-4.3726
22	6.6343	21.0210	-9.4456	28.0761	-6.7226	9.2151	4.0586	-5.3934	-3.2730
23	-2.1606	-9.4456	19.0175	-18.6657	10.7041	1.1620	-5.4849	10.8627	13.1182
24	29.5322	28.0761	-18.6657	74.9041	-16.2786	-13.2429	28.4617	-7.7209	-5.6358
25	-2.1718	-6.7226	10.7041	-16.2786	21.2834	-1.3935	-9.0192	15.3067	8.4260
26	-2.8498	9.2151	1.1620	23.2429	-1.3935	23.0794	4.9023	-1.6404	-1.5162
27	12.8744	4.0586	-5.4849	28.4617	-9.0192	4.9023	72.9656	-22.9046	-10.7040
28	-1.0228	-5.3934	10.8627	-7.7209	15.3067	-1.6404	-22.9046	25.1430	11.1736
29	-4.3726	-3.2730	13.1182	-5.6358	8.4260	-1.5162	-10.7040	11.1736	26.1117

APPENDIX B

Appendix B presents the matrix F

Appendix B

The Unrotated Matrix f

Dimension Number

Task Number	I	II	III	IV	V	VI	VII	VIII	IX
1	-1.8953	-2.2267	-0.2881	-1.3281	-0.0356	1.7716	-1.8905	0.7074	-1.6200
2	-3.1082	-1.6390	0.8934	-1.9339	0.7603	-0.6042	-1.6834	-0.6052	2.1328
3	-3.0103	-2.2599	0.4574	-1.4040	0.7762	-0.6831	-1.5591	-1.0577	1.9601
4	5.9625	-5.6606	-2.3208	1.4985	-1.9920	-0.7845	-1.9613	1.5519	-0.1723
5	0.4487	-2.7368	-1.8956	3.0948	-0.5184	-1.0444	-0.6462	-1.6234	1.4368
6	6.8261	5.4268	-1.6749	-4.6324	-0.9284	-1.1328	1.3967	-0.8080	0.7614
7	-0.3067	3.3095	0.4725	2.6865	-0.1216	0.3066	0.5695	1.0727	0.8089
8	-0.9712	0.6181	-1.0725	1.8708	-2.1178	1.0817	-0.6762	-0.9207	0.2093
9	-0.7122	3.3474	-3.6259	-0.6236	0.2958	-0.2258	-2.6272	-0.0981	-0.8700
10	-2.8113	0.1712	-1.1001	-0.7409	-3.1737	1.6425	1.1878	-0.8886	-1.5826
11	-1.2310	0.7299	1.6155	0.1432	1.7746	-1.0113	0.3830	2.8803	-1.6569
12	-3.1971	-0.1499	-1.5292	-0.4474	0.7482	0.9247	0.7473	1.1606	1.6225
13	-3.1159	-0.5210	1.3891	-1.4312	-0.9216	0.8307	-0.8230	0.6044	-0.7727
14	-0.4343	2.4125	1.0647	2.2790	2.6444	-1.7898	0.0335	-0.6787	-1.1366
15	-1.1550	2.9741	-1.0309	3.2100	-0.1533	-1.7678	0.2731	1.5834	-0.2676
16	-3.2866	-0.2905	-0.2315	-0.5020	2.3552	1.7566	1.1228	0.8563	1.9925
17	7.2243	-3.5081	-1.0886	-1.5754	2.6371	-0.5114	1.8839	0.6024	-0.2814
18	0.3273	-3.6613	-1.2988	-0.1771	-0.2845	-2.5904	1.6106	0.0212	-0.3333
19	-1.5906	2.5832	-2.7961	1.6081	-0.4052	2.0352	1.9607	0.8679	1.1197
20	-0.0071	4.1104	-2.7937	-2.0212	0.0272	-0.4460	-1.0191	0.3494	-0.4604
21	1.5706	1.5579	2.5533	-0.2401	0.3076	1.0936	-1.2583	0.9498	-0.2137
22	1.2625	2.5100	2.0135	1.3983	1.1480	-0.4821	-0.4954	-1.9204	-0.3371
23	-2.8564	-1.4188	1.1497	-1.7104	0.1518	1.4581	1.3398	-0.4408	-1.1197
24	5.5784	4.2705	5.0500	0.4007	-1.9513	0.3472	-1.0709	0.0181	1.4739
25	-1.6867	-2.6200	0.8951	-1.0445	-0.8092	1.8517	-0.8218	-0.2262	-0.5302
26	-0.3607	0.0322	-0.6907	1.8821	1.8821	0.6624	0.6387	-3.7690	-1.5738
27	6.9225	-3.7802	1.0701	1.1406	0.9766	3.6333	-0.0823	-0.1677	0.1323
28	-2.9005	-1.8067	2.7261	-0.8835	-0.4488	-1.5384	0.1201	0.2701	0.4687
29	-1.4265	-1.7751	2.0877	0.2821	-2.6245	-1.0802	3.3470	-0.2907	-0.1422

APPENDIX C

Appendix C presents the matrix of residuals after extraction of nine dimensions from matrix B^*

Appendix C

The Residual Matrix after Extraction of Nine Dimensions from the Matrix β^*

	1	2	3	4	5	6	7	8	9	10
1	5.4347	-2.9904	0.3735	1.9503	-0.0771	-3.4067	-1.7206	-2.3315	0.4553	-3.6640
2	-2.9904	5.0831	-1.3744	1.5417	-1.6107	-4.0078	3.4582	5.2907	-0.8728	1.9865
3	0.3735	-1.3744	6.8586	-3.6641	-2.1555	1.5061	-5.0877	-1.5607	1.6532	-0.2026
4	1.9503	1.5417	-3.6641	-8.2737	-2.1785	-6.6202	-4.9531	5.0023	5.6480	-1.1111
5	-0.0771	-1.6107	-2.1555	-2.1785	-0.7241	-5.0610	-1.6211	-3.5578	2.8547	-0.3889
6	-3.4067	-4.0078	1.5061	-6.6202	-5.0610	-11.4667	-6.4231	5.1937	10.6940	-1.9363
7	-1.7206	3.4582	-5.0877	-4.9531	-1.6211	-6.4231	4.3972	-0.3739	5.2046	0.8102
8	-2.3315	5.2907	-1.5607	5.0023	-3.5578	5.1937	-0.3739	7.4788	-1.3366	-0.5570
9	0.4553	-0.8728	1.6532	5.6480	2.8547	10.6940	5.2046	-1.3366	-8.5601	3.6144
10	-3.6640	1.9865	-0.2026	-1.1111	-0.3889	-1.9363	0.8102	-0.5570	3.6144	2.3319
11	-5.2121	0.7014	-0.5690	-1.7240	-4.6553	-2.1760	-4.7737	4.7381	4.2828	-1.1068
12	0.6738	-2.5860	-4.9850	-1.1574	4.5672	2.8220	-3.3260	-0.4590	3.9160	-2.5739
13	-1.3469	-0.6651	-0.0856	-1.8205	-1.1937	-2.9551	-1.6235	-2.7405	1.4451	0.6777
14	4.9591	-0.4104	-0.1300	-2.4429	1.0510	-2.5708	-3.8318	2.7354	1.7879	0.3706
15	-4.6768	-4.1446	9.0324	2.0040	-1.0298	-0.7753	-0.8969	-0.5162	-1.0630	-0.5438
16	-0.5908	0.3125	-1.3087	1.6259	-0.6581	-0.0646	-0.0519	0.7421	-0.5883	-1.5469
17	2.0440	4.5884	-1.6607	4.4382	1.1455	7.4020	3.8269	-3.2822	-8.4924	2.5811
18	-2.0139	1.5288	-0.8601	6.7938	2.6408	4.7902	7.4223	-4.9585	2.2308	-0.1081
19	4.1089	-2.0162	2.6010	-1.1854	0.0186	-0.6615	-0.5165	-2.1508	-2.5741	1.4746
20	5.1175	3.7570	-1.2352	4.1638	4.7470	6.1641	4.3669	-4.0156	-9.1668	-0.5288
21	0.5802	1.2832	-2.3589	-2.0510	1.4121	-2.0334	1.0037	-2.0216	2.9102	0.2389
22	-0.2971	1.7934	-0.8366	-2.4035	-2.7164	-3.3538	0.2057	2.6580	3.4570	0.8225
23	-0.7922	1.6077	-0.1315	-5.3451	-2.3799	-3.0249	-0.1093	2.8621	3.8324	0.9147
24	2.2066	-0.0292	-1.5182	5.6651	4.1651	8.9931	1.9260	-5.6976	-5.7992	-1.0207
25	-3.2459	-5.3165	1.8275	0.5114	1.8153	0.6828	-0.0707	-1.4249	-2.1988	-1.0402
26	-0.8196	-1.3084	-2.5668	-0.9104	1.0971	0.1592	-1.6709	-1.3298	0.1104	-2.8027
27	-3.4934	-4.0919	7.1885	3.1396	1.0678	1.5666	1.9174	0.9043	-1.8689	1.3090
28	3.0049	-1.6755	-0.1799	0.3030	1.0031	0.8529	3.4849	-0.2172	-1.7485	2.5944
29	5.7640	0.1684	1.4313	3.0515	2.4198	5.7218	-0.9708	0.9252	-9.8234	-0.6003

The Residual Matrix after Extraction of Nine Dimensions from the Matrix β^* (Con't.)

	11	12	13	14	15	16	17	18	19	20
1	-5.2121	0.6738	-1.3469	4.9591	-4.6768	-0.5908	2.0440	-2.0139	4.1089	5.1175
2	0.7014	-2.5860	-0.6651	-0.4104	-4.1446	0.3125	4.5884	1.5288	-2.0162	3.7570
3	-0.5690	-4.9850	-0.0856	-0.1300	9.0324	-1.3087	-1.6607	-0.8601	2.6010	-1.2352
4	-1.7240	-1.1574	-1.8205	-2.4429	2.0040	1.6259	4.4382	6.7938	-1.1854	4.1633
5	-4.6553	4.5672	-1.1937	1.0510	-1.0298	-0.6581	1.1455	2.6408	0.0186	4.7470
6	-2.1760	2.8220	-2.9551	-2.5708	-0.7753	-0.0646	7.4020	4.7902	-0.6615	6.1641
7	-4.7737	-3.3260	-1.6235	-3.8318	-0.8969	-0.0519	3.8269	7.4223	-0.5165	4.3669
8	4.7381	-0.4590	-2.7405	2.7354	-0.5162	0.7421	-3.2822	4.9585	-2.1508	-4.0156
9	4.2828	3.9160	1.4451	1.7879	-1.0630	-0.5883	-8.4924	2.2308	-2.5741	-9.1668
10	-1.1068	-2.5739	0.6777	0.3706	-0.5438	-1.5469	2.5811	-0.1091	1.4746	-0.5288
11	-0.9542	1.6395	1.3291	-0.1726	1.5129	0.5207	0.0062	2.7104	-1.2917	0.7756
12	1.6395	8.8602	0.1361	1.2197	-1.7604	-2.6355	-0.3647	-6.4067	-0.2642	-5.1984
13	1.3291	0.1361	4.8911	-1.6983	0.9056	0.3070	-0.2161	4.3487	0.3015	2.2966
14	-0.1726	1.2197	-1.6983	1.8326	-0.0516	0.8323	4.1223	2.7154	-0.4052	-1.9969
15	1.5129	-1.7604	0.9056	-0.0516	1.4126	-2.9911	1.6033	-7.7728	2.4284	3.2978
16	0.5207	-2.6355	0.3070	0.8323	-2.9911	7.6607	-2.4576	2.2034	1.0718	2.2071
17	0.0062	-0.3647	-0.2161	4.1223	1.6033	-2.4576	-5.9221	-3.4300	0.2531	-1.3750
18	2.7104	-6.4067	4.3487	2.7154	-7.7728	2.2034	-3.4300	3.3278	3.2076	-6.2488
19	-1.2917	-0.2642	0.3015	-0.4052	2.4284	1.0718	0.2531	3.2076	-0.5206	1.1197
20	0.7756	-5.1984	2.2966	-1.9969	3.2978	2.2071	-1.3750	-6.2488	1.1197	-2.4745
21	0.4441	-0.9121	-4.6655	-1.2745	-0.5636	0.0206	0.5847	-1.1259	-0.0541	2.0672
22	2.2169	-1.1075	-3.0197	-3.8186	-0.0711	1.2474	1.9512	2.1041	-1.8935	1.7094
23	-1.8524	-0.4517	-3.9738	-0.1586	2.2258	0.0705	1.4386	3.7679	-2.8531	1.8132
24	-1.0236	0.0677	5.1219	6.8954	-2.2340	-0.5001	-7.4392	-4.2055	2.9596	-4.3205
25	0.0332	4.7201	-0.4428	-2.9994	1.4787	-0.2473	-1.8411	-1.6257	-2.0008	1.8712
26	-2.1741	0.5444	3.9697	0.2027	-0.1994	0.4441	-0.9347	-0.8898	1.9305	2.3363
27	4.2514	0.4818	2.1309	-4.4272	1.0337	0.0982	2.1837	-3.0304	-1.0417	-5.0213
28	-0.0552	2.9127	-0.4824	-2.7096	-0.1555	-0.5010	3.3934	-0.2368	-0.8864	-4.6411
29	2.5744	1.6288	-0.9372	0.2924	2.5115	0.6681	-4.1432	-0.2050	-1.1560	-1.5826

The Residual Matrix after Extraction of Nine Dimensions from the Matrix β^* (Cont.)

	21	22	23	24	25	26	27	28	29
1	0.5802	-0.2971	-0.7922	2.2066	-3.2459	-0.8196	-3.4934	3.0049	5.7640
2	1.2832	1.7934	1.6077	-0.0292	-5.3165	-1.3084	-4.0919	-1.6755	0.1684
3	-2.3589	-0.8366	-0.1315	-1.5182	1.8275	-2.5668	7.1885	-0.1799	1.4313
4	-2.0510	-2.4035	-5.3451	5.6651	0.5114	-0.9104	3.1396	0.3030	3.0515
5	1.4121	-2.7164	-2.3799	4.1651	1.8153	1.0971	1.0678	1.0081	2.4198
6	-2.0334	-3.3538	-3.0249	8.9931	0.6328	0.1592	1.5666	0.8529	5.7218
7	1.0037	0.2057	-0.1093	1.9260	-0.0707	-1.6709	1.9174	3.4849	-0.9708
8	-2.0216	2.6580	2.8621	-5.6976	-1.4249	-1.3298	0.9043	-0.2172	0.9252
9	2.9102	3.4570	3.8324	-5.7992	-2.1988	0.1104	-1.8689	-1.7485	-9.8234
10	0.2389	0.8225	0.9147	-1.0207	-1.0402	-2.8027	1.3090	2.5944	-0.6003
11	0.4441	2.2169	-1.8524	-1.0236	0.0332	-2.1741	4.2514	-0.0552	2.5744
12	-0.9121	-1.1075	-0.4517	0.0677	4.7201	0.5444	0.4818	2.9127	1.6288
13	-4.6655	-3.0197	-3.9738	5.1219	-0.4428	3.9697	2.1309	-0.4824	-0.9372
14	-1.2745	-3.8186	-0.1586	6.8954	-2.9994	0.2857	-4.4272	-2.7096	0.2924
15	-0.5636	-0.0711	2.2258	-2.2340	1.4787	-0.1988	1.0337	-0.1555	2.5115
16	0.0206	1.2474	0.0705	-0.5001	-0.2473	-0.4441	0.0982	-0.5010	0.6681
17	0.5847	1.9512	1.4386	-7.4392	-1.8411	-0.9347	2.1837	3.3934	-4.1432
18	-1.1259	2.1041	3.7679	-4.2055	-1.6257	-0.8898	-3.0304	-0.2568	-0.2050
19	-0.0541	-1.8935	-2.8531	2.9596	-2.0008	1.9305	-1.0417	-0.8864	-1.1560
20	2.0672	1.7094	1.8132	-4.3205	1.8712	2.3363	-5.0213	-4.6411	-1.5826
21	-0.7888	-3.0984	0.2942	1.9646	2.8340	0.8602	1.3745	1.4588	1.6140
22	-3.0984	1.5203	-2.2329	1.9944	0.6572	0.1726	1.3698	-0.9406	1.9126
23	0.2942	-2.2329	-0.7937	1.0896	2.5838	-2.7068	4.3839	-1.8370	1.7531
24	1.9646	1.9944	1.0896	-7.3628	-0.8130	-1.7999	0.4917	-0.8534	-1.6271
25	2.8340	0.6572	2.5838	-0.8130	4.5908	1.4192	0.4691	-0.4856	-1.7461
26	0.8602	0.1726	-2.7068	-1.7999	1.4152	0.2271	2.4092	3.7538	1.2820
27	1.3745	1.3698	4.3839	0.4917	0.4691	2.4092	-5.8980	-5.5438	-3.3550
28	1.4588	-0.9406	-1.8370	1.7531	-0.4856	3.7538	-5.5438	3.3550	-0.8914
29	1.6140	1.9126	-1.8370	-1.6271	-1.7461	1.2820	-3.3550	3.3550	-0.8914